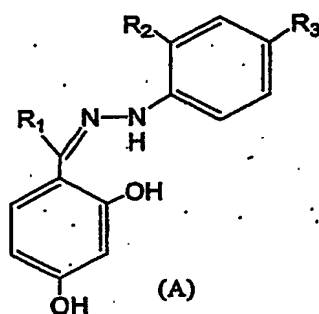


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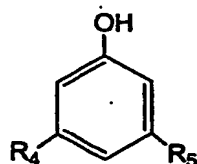
1. Nitrogen-oxygen-carbon polymers obtained by condensation of a 4-{1-[(2,4-di(substituted)-phenyl)-hydrazono]-alkyl}-benzene-1,3-diol with a phenol or a 3-substituted phenol or a 3,5-disubstituted phenol and formaldehyde or paraformaldehyde in the presence of either a basic (e.g. NaOH) or acid (e.g. HCl) catalyst in water/alcohol mixtures as solvent and at a temperature comprised between 20-150°C and having an average molecular weight comprised between 1000 and 50000, with the proviso that the 3-substituted phenol can not be resorcinol.
2. Polymers according to claim 1 wherein the 4-{1-[(2,4-di(substituted)-phenyl)-hydrazono]-alkyl}-benzene-1,3-diol is a compound of formula

(A):



- wherein R_1 is chosen in the group consisting of: hydrogen and a hydrocarbon radical, having from 1 to 10 carbon atoms, possibly halogenated;
- R_2 and R_3 each independently represent an electron-withdrawing group selected in the group consisting of hydrogen, halogen, acyl, ester, carboxylic acid, formyl, nitrile, sulphonic acid, linear or branched alkyl or aryl groups, having from 1 to 15 carbon atoms, optionally functionalised with halogens or joined to each other to form one or more condensed cycles with the phenyl ring, and nitro groups.
3. Polymer according to claims 1 and 2 wherein the 3,5-disubstituted phenol is a compound of formula (B):

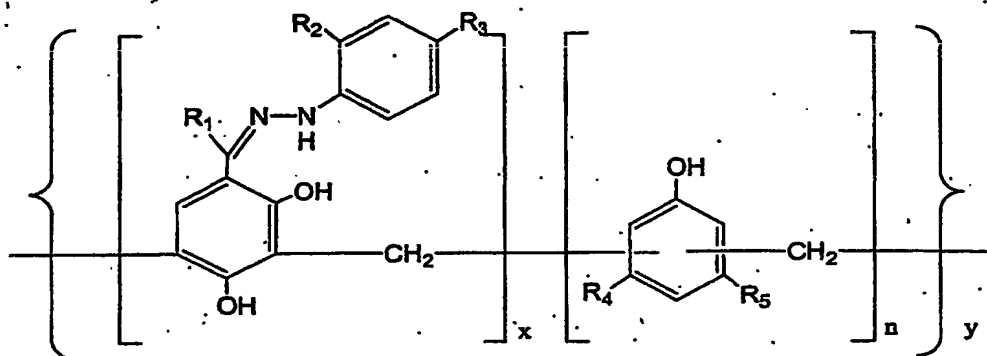
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(B)

wherein R_4 and R_5 each independently represent an electron-donating group selected in the group consisting of hydrogen, hydroxyl, ether, amines, aryl and linear and branched alkyl groups, having from 1 to 15 carbon atoms, with the proviso that the 3-substituted phenol can not be resorcinol.

4. Polymers according to Claims 1 – 3 having general formula (C)



(C)

wherein y can vary from 2 to 120, x can vary between 1 and 2, n can vary between 1 and 3 and R_1 , R_2 , R_3 , R_4 and R_5 are as above defined.

5. Metal complexes consisting of a polymer according to Claims 1 – 4 and a metal salt.

6. Metal complexes according to Claim 5 wherein the metal salt is chosen in the group consisting of iron-, cobalt- and nickel-carboxylates, -halides, -alcoholates, -acetylacetonates, -formates, -oxalates, -malonates, and analogous organic salts and mixtures thereof or -carbonates, -oxides and -bicarbonates, and mixtures thereof.

7. Complexes according to Claim 6 chosen in the group consisting of: Fe-, Co- and Ni-acetates (and mixture thereof).

8. Catalysts consisting of the complexes according to claims 5 – 7 wherein the metal is reduced either in the solid state with H_2 or in fluid solution systems with

appropriate reducing agents.

9. Catalysts consisting of the complexes according to claims 5 – 7 wherein the said metal complexes are pyrolysed at a temperature between 500 and 1000 °C, preferentially 800 °C, under inert gas protection (for example N₂, Ar) for about 2 hours.

10. Electrodes (anodes and cathodes) consisting of the catalysts according to Claims 8 – 9 and a suitable conductive support.

11. Anodes consisting of the catalysts according to Claims 8 – 9 and comprising binary or ternary combinations of Fe, Co and Ni and a suitable conductive support.

12. Cathodes consisting of the catalysts according to Claims 8 – 9 and comprising Ni or Co and a suitable conductive support.

13. A process for preparing a nitrogen-oxygen-carbon polymer according to Claims 1 – 4 wherein said reaction is carried out by condensation of a 4-{1-[(2,4-di(substituted)-phenyl)-hydrazono]-alkyl}-benzene-1,3-diol with a 3,5-disubstituted phenol and formaldehyde or paraformaldehyde in the presence of a basic catalysts.

14. A process according to claim 13 wherein said reaction is carried out in the presence of an acid catalyst.

15. A process according to claims 13 and 14 wherein said reaction is carried out in the temperature range from about 20 to about 150 °C and in the pH range from about 1 to about 14.

16. A process according to claims 13 – 15 wherein said reaction is carried out in either a one-pot or cascade procedure using as separated components a 4-acyl/formyl-benzene-1,3-diol, a 2,4-disubstituted phenylhydrazine, a 3,5-disubstituted phenol and formaldehyde or paraformaldehyde.

17. A process for preparing a complex according to claims 5 – 7 by dissolving a polymer according to Claim 1 – 3 and one or more salts in an appropriate solvent or mixture of solvents, preferentially acetone, in the temperature range from about 20 °C to about 60 °C and submitting the obtained product to reduction..

18. A process according to Claim 17 wherein a mixture of metal salts chosen in the group consisting of nickel(II), iron(II) and cobalt(II) salts, alone or in binary or

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ternary combinations in a preferred stoichiometric ratio is used.

19. A process according to Claim 18 wherein the metal(s) loadings are in the range of about 0.5 % to about 10 % of the total elements plus metal weight.

20. A process according to Claims 17 - 19 wherein the reduction step is performed with a flow of H₂ at a temperature between 350 °C and 400 °C for 1-2 hours.

21. A process according to Claims 17 - 19 wherein the reduction step is performed on the complex dispersed in a solvent, with an aqueous solution of hydrazine, or a solution of a tetrahydroborate salt [Y]BH₄, wherein Y is Li⁺, Na⁺, K⁺, NR₄⁺, PPN⁺ and R₄ is as defined in Claim 3 and PPN⁺ is bis(triphenylphosphoranylidene)ammonium, at a temperature between 0 °C and 20 °C for 30 minutes-1 hour.

22. A process for preparing a catalyst according to Claims 8 - 9 wherein the metal-doped polymers P-M are pyrolysed at temperatures ranging from 500 to 1000 °C under inert gas protection (for example N₂, Ar) for 1-2 hours.

23. A process for preparing an electrode according to Claims 10 - 11 in the form of anode for fuel cells, involving mixing together the metal doped polymer materials and either a porous carbon support material or other conductive support materials prior to the reduction treatment according to Claims 20 - 21.

24. A process according to claim 23 wherein a single metal or a binary or ternary combinations of nickel, iron and cobalt in a preferred stoichiometric ratio, with metal loadings in the range of about 0.5 % to about 10 % of the total elements plus metal weight are used.

25. A process for preparing an electrode according to Claims 10 and 12 in the form of alcohol-tolerant cathodes for fuel cells, comprising mixing together the metal doped polymer and either a porous carbon support material or other conductive support materials prior to heat-treatment at temperatures ranging from about 500 °C to about 1000 °C under inert gas protection (for example N₂, Ar) for 1-2 hours.

26. A process according to Claim 25 wherein the metal doped polymer contains a metal or a mixture of metals with metal loadings in the range of about 0.5 % to about 10 % of the total carbon plus metal weight.

27. Anodes for Direct Oxidation Fuel cells (DOFC) or Direct Alcohol Fuel Cells (DAFC), formed with a catalysed carbon substrate according to Claims 23 - 24 containing metals chosen in the group consisting of iron, cobalt and nickel.

28. Alcohol-tolerant cathodes for Direct Oxidation Fuel cells (DOFC), or Direct Alcohol Fuel Cells (DAFC), formed with a catalysed carbon substrate according to claims 25 - 26, containing nickel.

29. Direct Oxidation Fuel Cells (DOFC) or Direct Alcohol Fuel Cells (DAFC) comprising an anode and a cathode according to claims 11 and 12 and a solid electrolyte membrane, either anionic or cationic, capable of producing open circuit voltages (OCV) as high as 1.13 V and powers as high as 160 mW/cm² at ambient temperature and pressure.

30. Polymer Electrolyte Fuel Cells (PEFC) fuelled with H₂ comprising an anode catalysed with iron, cobalt and nickel in a stoichiometric ratio with an overall metal loading between 0.5 and 8% wt according to Claim 11 capable of producing open circuit voltages (OCV) as high as 1.18 V and power densities as high as 300 mW/cm², in conjunction with a cathode of the present invention or a cathode of the state of the art and a solid electrolyte membrane of the state of art.

31. Polymer Electrolyte Fuel Cells (PEFC) fuelled with H₂ comprising a cathode catalysed by nickel in loadings between 0.5 - 7% wt according to Claim 12 capable of producing open circuit voltages (OCV) as high as 1.18 V and power densities as high as 300 mW/cm² in conjunction with an anode of the present invention or an anode of the state of the art and a solid electrolyte membrane of the state of art.

32. Fuel cells comprising electrodes according to claims 10 - 12.